RevMexAA (Serie de Conferencias), **16**, 257–258 (2003)

FOLLOW-UP SCIENCE OF THE *SIRTF* GTO COSMOLOGICAL SURVEY PROGRAM WITH THE GTC

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RESUMEN

En este artículo se describen los Programas de Búsquedas Cosmológicas y de Distribuciones Espectrales de Energía de AGN que se van a realizar con *SIRTF*/MIPS. Estos programas tienen como objetivos fundamentales entender la evolución cosmológica de la tasa de formación estelar medida con la emisión en el infrarrojo (IR) lejano, estimar la fracción de la emisión en el IR lejano que se origina en AGN, resolver el fondo IR lejano en galaxias, y buscar nuevas clases de galaxias. Los datos de *SIRTF* por si solos no nos van a permitir distinguir entre AGN y galaxias con formación extrema basándonos en experiencias previas con *IRAS* (por ejemplo el caso de las galaxias IR ultraluminosas, ULIRGs). Además necesitaremos confirmación espectroscópica de los desplazamientos al rojo obtenidos fotométricamente con datos de *SIRTF*. En este artículo se proponen varios ejemplos de posibles observaciones con instrumentos que trabajarán en el GTC de objetos descubiertos en las Búsquedas Cosmológicas de *SIRTF*, para resolver algunas de las cuestiones propuestas anteriormente.

ABSTRACT

In this paper we describe the *SIRTF*/MIPS Cosmological Survey and the AGN Spectral Energy Distribution Programs. These programs are aimed at understanding the csmological evolution of star formation rate traced by the far infrared (IR) emission, to estimate the fraction of far-IR light from AGN, to resolve the far-IR background into galaxies, and to look for possible new classes of galaxies. The *SIRTF* photometric data alone will not be able to distinguish between AGN and powerful starbursts, based on experience from the ultra-luminous IR galaxies (ULIRGs) discovered by *IRAS*. In addition, we will need spectroscopic confirmation of the photometric redshifts of the sources detected. In this paper we describe a few examples of possible follow-up observations with the GTC of sources detected by the *SIRTF* Cosmological Survey Program.

Key Words: **INFRARED : GALAXIES**

Science with the GTC 10-m Telescope (Granada, España, 5-8 febrero 2002)
Editors: José Miguel Rodríguez Espinosa, Francisco Garzón López & Verónica Melo Marín

1. INTRODUCTION

The *Space IR Telescope Facility* (*SIRTF*) is the fourth and final element in NASA's family of Great Observatories. The Observatory carries an 85 cm cryogenic telescope and three cryogenically cooled science instruments capable of performing imaging and spectroscopy in the 3.6–160 μm range.[1] In this article we will review two of our Guaranteed Time Observers (GTO) Programs and possible follow up science with the GTC.

2. THE *SIRTF* GTO COSMOLOGICAL SURVEY PROGRAM

The *SIRTF* Cosmological Survey Program is an observational program to be conducted by the Guaranteed Time Observers (GTO) using the Multiband Imaging Photometer for *SIRTF* (MIPS) and the IR Array Camera (IRAC). These two instruments will provide broad band imaging at 3.6, 4.5, 5.8, 8, 24, 70, and 160 μm. The whole program accounts for 5% of the total time available on *SIRTF*. The goals of the survey include elucidating the cosmological evolution of star formation rate as traced by the far-IR emission, estimating the fraction of far-IR light from AGN, resolving the far-IR background into galaxies, and looking for possible new classes of galaxies.

We will conduct three cosmological surveys with *SIRTF*: i) The *Shallow Survey:* will cover one field of 9 deg $\times$9 deg on the NOAO Deep Wide-Field Survey (NWDFS); ii) the *Deep* survey will cover six fields of 0.4 deg $\times$0.4 deg; iii) the *Ultradeep* survey will cover one field of $70' \times 70'$ (the Groth Strip). Complementary observations (imaging and spectroscopy) of the MIPS GTO fields are or will be performed with IRS on *SIRTF* (5–38 μm spectroscopy), *Chandra*, ESA's

[1]We refer the reader to the *SIRTF* webpage for more information on the Observatory and instrument capabilities (http://sirtf.caltech.edu/SSC/).

XMM–Newton, and *HST*, as well as ground-based telescopes[2].

3. THE GTO AGN SPECTRAL ENERGY DISTRIBUTION (SED) PROGRAM

The *SIRTF* AGN SED program goals include understanding the far-IR properties of luminous AGN and providing the *SIRTF* Cosmological Survey Program with accurate templates for classifying the newly discovered objects. We have selected AGN from a number of catalogues based on different observational properties: X-ray brightness, optical brightness (PG quasars), high frequency radio brightness (the 3C Catalogue), and IR emission (luminous and hyperluminous *IRAS* galaxies). From the complete AGN catalogues, we have drawn the most luminous examples (10–20 objects) at redshifts of $z < 0.4$. We have supplemented the core sample with a subsample of high redshift quasars to probe evolutionary trends. All the targets will be observed with MIPS. For approximately one third of the sample we will obtain additional observations with MIPS on SED mode ($R = 15$–25 in the 55–90 μm spectral range) and low and high resolution spectroscopy with the IR Spectrograph (IRS) between 5 and 40 μm.

A two-color diagram produced with the MIPS photometric bands (i.e., f_{70}/f_{160} vs. f_{70}/f_{24}) can be used to obtain a crude determination of the redshift and object class for the newly discovered population of galaxies by the GTO surveys. For instance, it will help distinguish between a hyperluminous IR galaxy, a quasar and an Arp 220-like object (see Hines & Low 1999 for more details).

4. FOLLOW-UP SCIENCE WITH THE GTC

Since a significant fraction of the bolometric luminosity is absorbed by dust and re-emitted in the IR, the far-IR luminosity offers an estimate of the star formation rate (SFR), especially for dust-rich environments thought to be common at high z. Hence, the measured MIPS far-IR luminosities of the newly discovered population of luminous starbursts will provide an estimate of the cosmological evolution of the SFR. However there will be a degeneracy of the peak of the far-IR SED between the redshift of the galaxy and the SFR (see for instance figure 16b in Misselt et al. 2001). Other factors that will affect the location of the peak and shape of the SED are the geometry of the emitting region, the optical depth, and the properties of dust. See also Kennicutt (2000) for a detailed description of SFR indicators.

OSIRIS (see Cepa et al., this volume, p. 13) on the GTC could be used to obtain multiobject optical spectroscopy of selected galaxies in fields of $8' \times 8'$. This will provide a spectroscopic confirmation of the *SIRTF* photometric redshifts. In addition, the optical spectra (line widths and ratios), combined with the X-ray properties of the galaxies, will allow us to distinguish between AGN and powerful starbursting galaxies.

For galaxies at redshifts $z \simeq 0.8$–3 the Hα emission line will be redshifted into the near IR (1–2.4 μm). Hα, together with the far-IR luminosities, can be used to probe the cosmological evolution of the SFR (e.g., Madau 1998). EMIR (see Garzón et al., this volume, p. 23) on the GTC, a near-IR multiobject spectrograph, could provide an efficient way of obtaining near-IR spectroscopy of selected galaxies in a field of view of $6' \times 3'$. For galaxies at $z < 0.8$, Hα still appears in the optical range, and OSIRIS can be used instead. These observations will allow us to constrain simultaneously the geometry and properties of the obscuring dust, and the star formation properties of galaxies (in particular their SFRs), as a function of redshift. In addition, both EMIR and OSIRIS have imaging capabilities that can be used for detailed morphological studies of galaxies detected in the *SIRTF* Cosmological Surveys.

We acknowledge support from Contract 960785 through the Jet Propulsion Laboratory.

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[2]More details available at http://lully.as.arizona.edu/.